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4 A machine for simultaneously measuring and compounding angles about multiple axes

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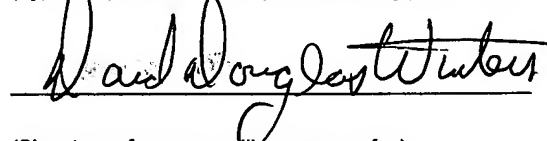
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1 Title of the Invention

2 A machine for simultaneously measuring and compounding angles about multiple axes

3

4 Cross Reference to Related Applications

5 Not Applicable

6

7 Statement Regarding Federally Sponsored Research or Development

8 Not Applicable

9

10 Description of Attached Appendix

11 Not Applicable

12

13 Background of the Invention- -Field of Invention

14 This invention relates generally to the field of electronic levels and more  
15 specifically to a machine for measuring and for compounding angles about more than  
16 one axis at one time.

17

18 Background of the Invention

19 Level measuring devices have been known and used for literally thousands of  
20 years. The first form was in all probability the free hanging plumb line. With the advent  
21 of glass-blowing technology, the bubble level eventually became possible and could be  
22 made capable of graphically approximating the attitude of a surface on two axis at once.

1 In recent decades, new electronic sensing technologies became available that  
2 can measure inclination to a precise degree heretofore unknown while being practically  
3 impervious to jarring and jolts that would have rendered previous devices useless.

4 Additionally, prior technology did not provide for establishing arbitrary reference  
5 baselines or zero points with respect to which angle could be measured. The reference  
6 was always the vertical as defined by gravity.

7 US patents 5,259,118 and 5,956,260 both to Charles E. Heger, teach electronic  
8 inclination sensors/displays that measure inclination about a single axis and show the  
9 results in a fan shaped graphic that bears little resemblance to read-outs familiar to  
10 professional engineers or construction workers.

11 US patent 6,037,874 issued to Gregory Heironimus, also teaches an electronic  
12 level measuring device with graphic display that measures angles about a only single  
13 axis. US patent 5,335,190 issued to Nagle et al. discloses an inclinometer for  
14 measuring and rescaling an angle about a single axis and digitally displaying the result.

15 Since prior electronic inclinometer technology could only measure angles about  
16 individual axes, independently, then if, for example, one wanted to measure the slope  
17 angle of a table that was out of level, one had to measure the slope along two different  
18 edges and then use this data to calculate the compound angle. The same problem  
19 presents itself to a civil engineer who wants to know the slope of a land surface. The  
20 only other manual method for measuring the angle of a plane (avoiding on-the-spot  
21 mathematical calculations) was imprecise and involved swinging an inclinometer across  
22 the surface, noting the maximum angle displayed during the sweep, that angle being an  
23 approximation of the compound angle.

1           In another example, the driver of a mobile vehicle traversing a meandering  
2 course across a slope could not, previously, measure his/her actual maximum angle of  
3 tilt. At best, the driver could only determine the angle with respect to one or two given  
4 individual axes, neither of which might actually properly aligned to measure the slope of  
5 the surface across which the vehicle traveled.

6           No electronic leveling system has been introduced to precisely measure angles  
7 in more than one axis at once and combine them after the natural but imprecise manner  
8 of the old bubble level technology familiar to carpenters, for example, world-wide.

#### 9 10   Objects of the Invention

11           The primary object is to provide an inclinometer / leveling / angle measuring  
12 device that can measure angles around two axis at once and display them separately or  
13 combine and/or display them as a compound angle.

14           Another object is to provide an inclinometer that can display single axis or  
15 compound angles both graphically and/or in numeric modes.

16           Another object is to provide an inclinometer that can display angles in discrete  
17 and/or continuous modes of increasing preciseness, from approximate to significantly  
18 more exacting.

19           A further object is to provide an inclinometer that can measure angles relative to  
20 virtually any chosen observable baseline or reference even those that are remote or  
21 distant, using them to establish a baseline or zero point of reference.

22           A further object is to provide an inclinometer that can record in memory and/or  
23 display various measurements for later reference.

1 Another object is to provide an inclinometer that can measure angles to distant  
2 objects or points of reference relative to the vertical or relative to an arbitrary reference  
3 angle.

4 Other objects and advantages will become apparent from the following  
5 descriptions, taken in connection with the accompanying drawings, wherein, by way of  
6 illustration and example, an embodiment is disclosed.

#### 7 8 Brief Summary of the Invention

9 In accordance with a preferred embodiment, there is disclosed a machine to  
10 measure angles about two axes at once and to calculate the compounded angle.  
11 Previous devices in this vein are often termed "inclinometers" or "levels." This device  
12 can measure angles about more than one axis at a time and display the measurements  
13 separately or combine and display them as compound angles. The display may be  
14 graphic, numerical or both and may manifest discrete or continuous modes of  
15 increasing preciseness, from the approximate to the significantly more exacting. The  
16 machine may also record results in memory for later display. The zero points or  
17 baselines with respect to which measurements are taken may relative to plumb-line  
18 vertical or they may be chosen arbitrarily. Further, the device may provide for  
19 orientation against remote or distant references.

20 Other objects and advantages of the present invention will become apparent  
21 from the following descriptions, taken in connection with the accompanying drawings,  
22 wherein, by way of illustration and example, an embodiment of the present invention is  
23 disclosed.

## Brief Description of the Drawings

The drawings constitute a part of this specification and include exemplary but not all-inclusive embodiments that may comprise various forms. It is to be understood that in some instances various aspects may be shown exaggerated or enlarged to facilitate an understanding of the invention.

Fig. 1 is a plan view of the machine showing the display in both numeric and graphic modes.

Fig. 2 contains  $\frac{3}{4}$  views of the machine in vertical and horizontal positions, functioning in graphic mode.

Fig. 3 contains  $\frac{3}{4}$  views of the machine in vertical and horizontal positions functioning in numeric mode

Fig. 4 is a schematic block diagram of the machine.

## List of Numbered Components for Each Figure

### Fig. 1

- 10 case
- 20 display screen
- 30 tilt sensor module
- 40 microprocessor (contains thermister)
- 50 power supply and voltage regulator
- 60 laser reference pointer
- 70 display orientation mode indicator (numeric format)
- 80 x-axis angle display (numeric format)
- 90 y-axis angle display (numeric format)

- 1        100    temperature display (numeric format)
- 2        110    compound angle display (numeric format)
- 3        111    compound angle direction line (numeric format)
- 4        112    curved tube bubble level display (graphic format)
- 5        113    round dome bubble level display (graphic format)
- 6        120    display orientation mode selector
- 7        130    on/off/reset button
- 8        140    record data selector
- 9        150    laser reference pointer control
- 10       155    communications port

11

12       Fig. 2

- 13       160    device in vertical position using curved tube bubble level display
- 14       170    device in horizontal position using round dome bubble level display

15

16       Fig. 3

- 17       180    device in vertical position using numeric display
- 18       190    device in horizontal position using numeric display

19

20       Fig. 4

- 21       20    display screen
- 22       30    tilt sensor module
- 23       40    microprocessor (contains thermister)
- 24       50    power supply and voltage regulator

## Detailed Description of the Preferred Embodiment

Detailed descriptions of the preferred embodiment are provided herein. It is to be understood, however, that the present invention may be embodied in various forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but rather as a basis for the claims and as a representative basis for teaching one skilled in the art to employ the technology presented in virtually any appropriately detailed system, structure or manner.

Referring first to Fig.1 there is depicted a plan view in the preferred mode showing the display in both numeric format (20) and graphic format (112 and 113). The case (10) made of a rigid substance such as, for example, plastic, wood, ceramics, or metal, is used to mount and contain the several components and is used to orient the device by pressing it against solid objects or by training the laser pointer (60) on distant points on objects in order to measure the angles to or of those objects. The tilt sensor module (30) contains two sensors each oriented about a different axis, the axes being normal to each other and lying in the same plane.

When the device is in use, the microprocessor (40) and display screen (20) are energized by the power supply/voltage regulator that is, in preferred mode depicted, a 9 volt dry cell (50). The microprocessor (40) receives data inputs from the tilt sensors (30) converts the data into usable information as to discrete and/or compound angles. It also receives and processes the output of its thermister to generate a temperature display output (100). The microprocessor (40) then forwards the results for display on the display screen (20) in numeric format (110), graphic horizontal (curved-tube bubble-level like) display format (112), or graphic vertical (round-dome bubble-level like) display format (113).



1           The format button (120) is used to select the display format (numeric or graphic)  
2 preferred. The "ON/OFF/RESET" button (130) is used to switch the machine on and off  
3 and to internally mark a particular orientation of the machine for use as a baseline/zero  
4 point against which subsequent angles may be measured. The memory button (140) is  
5 used to record measurements and calculations for later reference. The laser button  
6 (150) is used to activate the laser reference pointer (60).

7           To exercise this embodiment, one presses the "ON/OFF/RESET" button (130)  
8 and orients the measuring device by pressing the case against one surface the angle of  
9 which one desires to measure. The display screen (20) will then show numeric or  
10 graphic information relative to the vertical as defined by gravity. (The device will  
11 automatically generate its output values according to whether it is positioned with its  
12 display facing upward or with facing to one side.) At this point, one may simply observe  
13 the information, or record the information by pressing the "MEMORY" button (140).

14           Additionally, one may again press the "ON/OFF/RESET" button (130) to redefine  
15 the baseline/zero point to equal the present orientation. Then the device may be moved  
16 to a new position and it will measure the new angle inscribed relative to the orientation  
17 had at the time the "ON/OFF/RESET" button was last pushed. At this point, the output  
18 values may again be observed or they may be recorded by pushing the "MEMORY"  
19 button (140) for later reference.

20           If the user desires to measure an angle to a remote point, he/she may substitute  
21 the laser reference pointer (60) for physical contact with the surfaces to receive angular  
22 measurement. Instead of the pressing the device against the surface(s) in question,  
23 the user activates the laser reference pointer by pressing the "LASER" button (150) and

1 trains it on the distant reference point to orient the device. The user then otherwise  
2 proceeds as described above.

3 The user may alternate the display formats by pressing the "MODE" button (120).  
4 If the display is in "graphic" format, the micro-processor converts the output data to a  
5 graphic display resembling a carpenters bubble level. In this format, if the device is  
6 oriented with its display screen (20) to one side, the image displayed will resemble a  
7 curved-tube bubble-level (112) measuring an angle about only one axis. If the device is  
8 oriented with its display screen (20) pointing upward, the image displayed will resemble  
9 a dome-shaped bubble level (113), exhibiting the compound angle measured and  
10 calculated with reference to two axes.

11 If the display is in "numeric" format, it will initially exhibit a single angle relative to  
12 the vertical. Set to use such a format, if the display screen is facing to one side (i.e. is  
13 substantially normal to a horizontal plane) the "display mode indicator" will spell out  
14 "VERT". However, if the display screen is facing upward (i.e. substantially parallel to a  
15 horizontal plane), it will it will initially exhibit the angles about two axis normal to each  
16 other, plus their compound angle. The "display mode indicator" will spell out "HORIZ."  
17 As a design option, the "display mode indicator" also may be rigged to exhibit a  
18 "compound angle direction line" (111) showing the direction along which this compound  
19 angle lies. When in the "numeric" format, the preferred embodiment also measures  
20 and displays the temperature (100) as measured by the thermister in the  
21 microprocessor (40), which may be useful in calculating material expansion/contraction  
22 corrections with respect to the physical entities dealt with.

23 When the device is powered up and oriented, the angular measurements are  
24 sampled repeatedly at frequent intervals. The values and calculated results of each

1 measurement are continuously averaged into any immediately previous results to refine  
2 the accuracy of the final output. Thus, while the device remains stationary, accuracy of  
3 the final output may be increased to a high degree of precision within a period of several  
4 seconds.

5 Fig. 2 is a schematic block diagram of the machine showing the micro-processor  
6 (20) that is central to the machine, incorporating an analog to digital converter, timers,  
7 digital input/output ports, SRAM, FLASH and EPROM circuits, a thermister for  
8 measuring temperature and an SPI channel. The figure relates this processor (40) to  
9 the tilt sensor module (30), the display screen (20), the "ON/OFF/RESET" button (30),  
10 the "MODE" button (120), the "MEMORY" button (140), the "LASER" button (150), and  
11 the power supply/voltage regulator (50), powering both the microprocessor (40), display  
12 screen (20), and communications port (155).

13 While described herein is a preferred embodiment, it is not intended to limit the  
14 scope to the particular form set forth, but on the contrary, it is intended to cover such  
15 alternatives, modifications, and equivalents as may be included within the spirit and  
16 scope as defined by the appended claims.